APPENDIX B

CLEAN VERSION OF AMENDED SPECIFICATION

Hydrogen Peroxide Based Propulsion System

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BACKGROUND OF THE INVENTION

(1) Field Of The Invention

The invention relates to hydrogen peroxide (H_2O_2) engines and in particular to a novel hybrid rocket/turbine hydrogen peroxide based engine and hydrogen peroxide based propulsion system for micro air vehicle propulsion.

(2) Description Of The Prior Art

Micro air vehicles (MAVs) play a key role in military and surveillance operations. For these MAVs, a range of engine characteristics is needed to meet specific requirements, such as low speed, low noise, high speed, etc. In this specification MAVs are defined as air vehicles which have a wingspan of 1 metre or less and/or a weight of 2kg or less. Features such as weight, ease of starting, reliability, etc. are important in the choice of the power plant. Air breathing engines or motors are usually attractive on weight grounds because they do not have to carry their own oxidant. However this may not be so important at small scales when the mass of the engine itself is relatively high. In addition, of course, small engines have relatively poor thermal and propulsive efficiency due to low cycle temperatures.

Hydrogen peroxide engines are known. The inventors have determined that these engines can be built small enough and give adequate performance requirements for use in MAVs. Hydrogen peroxide can nowadays be generated 'in the field' by electrolytic techniques. It can be decomposed catalytically to produce steam and oxygen at high temperature and is an acceptable

propellant in its own right with a high specific thrust and a low infrared (IR) signature.

SUMMARY OF THE INVENTION

The invention comprises a micro engine comprising a source of hydrogen peroxide and a source of hydrocarbon fuel; a decomposition region for decomposition of hydrogen peroxide and a combustion region for combustion of hydrocarbon fuel with oxygen produced from such decomposition; and a nozzle to exit products of such decomposition and combustion.

Further is provided a micro air vehicle equipped with such an engine and a method of propelling a micro air vehicle comprising the steps of decomposing hydrogen peroxide, combusting a hydrocarbon fuel with oxygen produced from such decomposition, and exiting products of such decomposition and combustion through a nozzle.

The invention also comprises a micro air vehicle having an engine having connection means to a tank adapted to contain hydrogen peroxide, a fuel tank connected to a region adapted to decompose hydrogen peroxide, a decomposition region/chamber suitable for decomposing hydrogen peroxide, a nozzle to accelerate the resulting decomposition products, a turbofan located downstream of the exit of said nozzle and located within a duct so as to provide propulsive thrust and means to provide a hydrocarbon fuel adapted to burn by consuming oxygen from the decomposition of hydrogen peroxide.

DESCRIPTION OF THE CURRENT EMBODIMENT

The invention will now be described by way of example only and with reference to the following figures of which:

Figure 1 shows an embodiment of the invention comprising a decomposition and combustion chamber/nozzle and a ducted fan.

In a simple embodiment of the invention, a MAV power plant 1 includes a fuel tank 2 containing 34g of H_2O_2. To hold this weight of fuel, the fuel tank can be a simple cylinder (2cm in diameter and 7.5cm in length). The fuel tank alone will weigh about 16g if it is made of aluminium and its thickness (1mm) should be sufficient to contain the pressure inside the tank. The fuel tank is connected to a decomposition and combustion chamber/nozzle 5 of weight less than 2g.

The decomposition of H_2O_2 is an exothermic process in which a substantial rise in temperature occurs. Thermodynamic calculations on a 90% H_2O_2 solution show that a temperature of 1022K (749°C) and a pressure of 35.5bar (515psi) are achievable when the decomposition products are allowed to expand adiabatically to atmospheric pressure.

A simple convergent/divergent nozzle is used in the flow parameter calculations necessary to diminish the combustion chamber pressure and nozzle exit area. A chamber pressure of 2.07bar (30psi) and a nozzle exit diameter of about 2mm will produce a mass flow through the nozzle of about 0.17g/s and an nozzle exit velocity of M 1.1. The thrust produced now is about 0.124N which is comparable to the amount required to propel an MAV.

In a preferred embodiment, a bipropellant system uses hydrocarbon fuel to consume the excess oxygen. This system uses an additional tank 3 to store the hydrocarbon. This has a clear

advantage in endurance over a monopropellant system. However, the gain in endurance must weigh against the increase in combustion temperature and complexity in the fuel system. At temperatures in excess of 2400K, very few materials will be suitable for making the combustion chamber. Also, very efficient cooling techniques must be implemented to avoid damage to the combustion chamber. Preferably the propulsion system utilises hydrogen peroxide and kerosene as fuel and oxygen as the oxidant. A bipropellant (H_2O_2 and kerosene) propulsion system has a 70% improvement on flight endurance but has high exhaust temperature (circa 2700K) which makes the design and selection of material for the combustion chamber/nozzle very challenging. A bipropellant system with on-board oxygen gives the best flight endurance.

In the most preferred embodiment the system comprises a bipropellant system as described above with the addition of a ducted fan. Such an arrangement is not known per se. Figure 1 is a figure showing the arrangement 4 of a hydrogen peroxide based ducted fan engine comprising a decomposition and combustion chamber/nozzle arrangement 5, and a turbofan 6 comprising turbine 7 and fan 8 arranged within a duct 9. In the ducted fan engine design, air passes around the outside of the decomposition and combustion chamber/nozzle. The front of the decomposition and combustion chamber has to be shaped to avoid flow separation. The combustion chamber/nozzle 5 will attain very high temperatures during operation and the bypass flow will help to cool the nozzle. For a bypass ratio of 10, the duct exit flow velocity is found to be about 300m/s and the duct exit is 3mm in diameter. The fan rotational speed is estimated to be 1.63E6rpm. This is due to the small size of the fan. These calculations are based on a nozzle throat area of 1mm diameter. The total thrust produced by this engine is 0.634N. The hydrocarbon based fuel is also burnt within the

decomposition and combustion chamber, at least in part using oxygen produced by the decomposition of hydrogen peroxide.